

# Mega-Precovery and data mining of NEAs and other solar system objects

M. POPESCU<sup>1,2</sup>, O. VADUVESCU<sup>3,2</sup>, F. CHAR<sup>4</sup>, L. CURELARU<sup>5,6</sup> and the EURONEAR team

- <sup>1</sup>The Astronomical Institute of the Romanian Academy (AIRA), Bucharest, Romania  
<sup>2</sup>Institut de Mécanique Céleste et de Calculs des Ephémérides, Observatoire de Paris, France  
<sup>3</sup>Isaac Newton Group of Telescopes, Santa Cruz de la Palma, Canary Islands, Spain  
<sup>4</sup>Unidad de Astronomia, Universidad de Antofagasta (UAUA), Chile  
<sup>5</sup>The Romanian Society for Meteors and Astronomy (SARM), Romania  
<sup>6</sup>Brasov Astroclub, Romania



## ABSTRACT

The vast collection of CCD images and photographic plate archives available from the world-wide archives and telescopes is still insufficiently exploited. Within the EURONEAR project we designed two data mining software with the purpose to search very large collections of archives for images which serendipitously include known asteroids or comets in their field, with the main aims to extend the arc and improve the orbits.

In this sense, "Precovery" (published in 2008, aiming to search all known NEAs in few archives via IMCCE's SkyBoT server) and "Mega-Precovery" (published in 2010, querying the IMCCE's Miriade server) were made available to the community via the EURONEAR website.

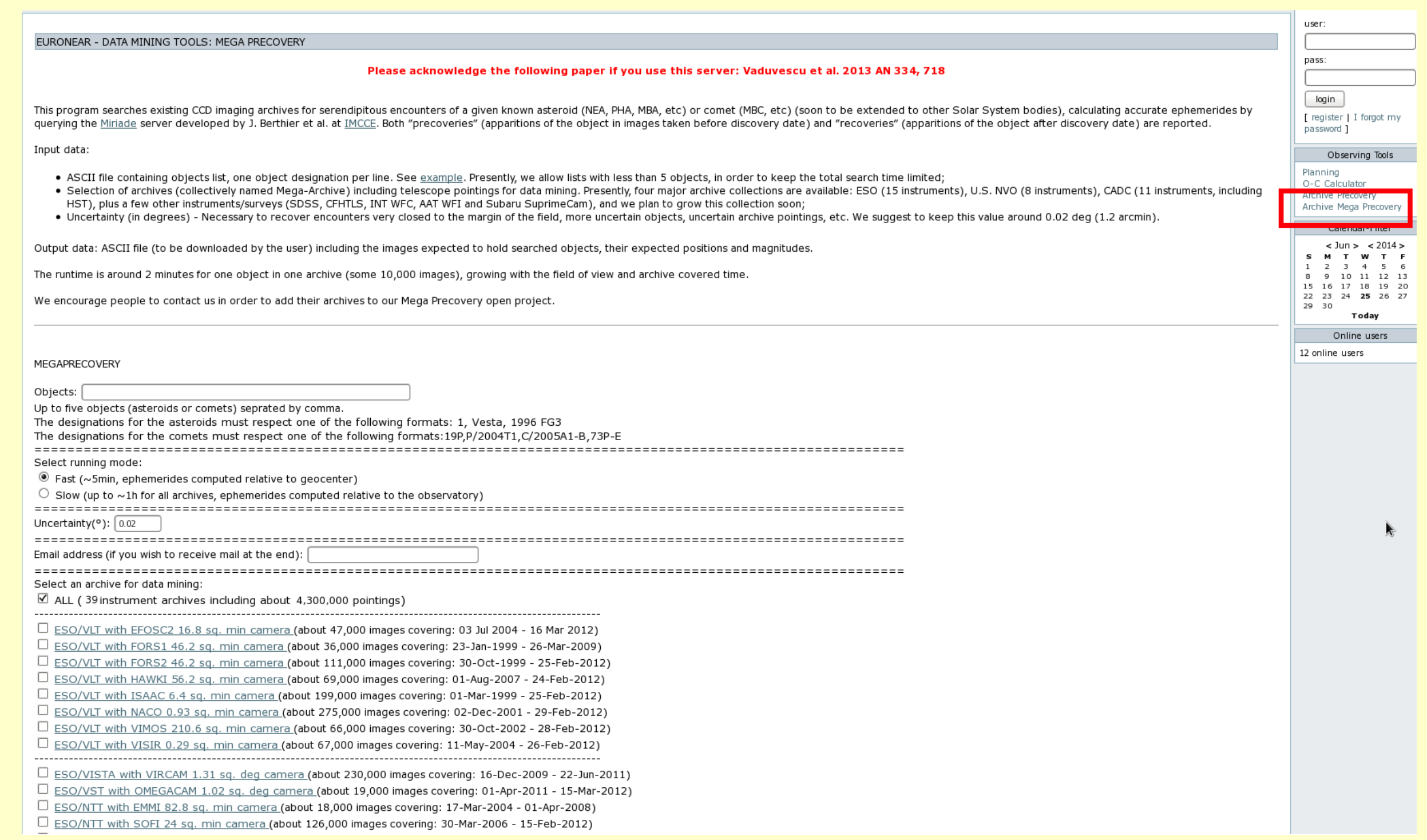
Mega-Precovery aims to search one or a few known asteroids or comets in a mega-collection including millions of images from some of the largest observatory archives: ESO (15 instruments served by ESO Archive including VLT), NVO (8 instruments served by U.S. NVO Archive), CADC (11 instruments, including HST and Gemini), plus other important instrument archives: SDSS, CFHTLS, INT-WFC, Subaru-SuprimeCam and AAT-WFI, currently adding together 39 instruments and 4.3 million images (Mar 2014), and the Mega-Archive is growing!

Here we remind the main capabilities of Mega-Precovery, presenting some of its most important results and projects. Particularly, the following search capabilities will be added to soon: the ING archive (all imaging cameras) will be included and new search options will be made available (such as query by orbital elements and by observations) in order to target new Solar System objects such as Virtual Impactors, bolides, planetary satellites, TNOs (besides the comets added recently). In order to characterize the archives, we introduce the "AOMegaA" factor (archival etendue) proportional to the AOMega (etendue) and the number of images in an archive.

With the aim to enlarge the Mega-Archive database, we invite the observatories (particularly those storing their images online and also those owning plates archives which could be scanned on request) to contact us in order to add their instrument archives (consisting of an ASCII file with telescope pointings in a simple format) to our Mega-Precovery open project.

## MEGA-PRECOVERY WEB INTERFACE

<http://euronear.imcce.fr/tiki-index.php?page=MegaPrecovery>



## RUN SAMPLES AND FEW IMPORTANT RESULTS

**Astrometry** - fast targeted search of some of the most important objects, such as PHAs or VIs. However, all asteroids and comets can be searched using MegaPrecovery. Examples of important orbital improving using EURONEAR data mining tools and Subaru SuprimeCam archive:

- 2012 RX16: 3 months arc extended to 8 years (MPS 492076);
- 2007 TK15: 1 month arc extended to 1.5 years (MPS 505407);
- 2011 GM44: 1 month arc extended to 5 years (MPS 506465);
- 2012 KC6: 2 months arc extended to 4 years (MPS 504077);
- 2012 HC34: 6 months arc extended to 10 years (MPS 504077);
- 2009 UE2: 5 months arc extended to 2 years (MPS 505424);
- 2011KW19: 2 month arc extended to 7 years (MPS 506468).

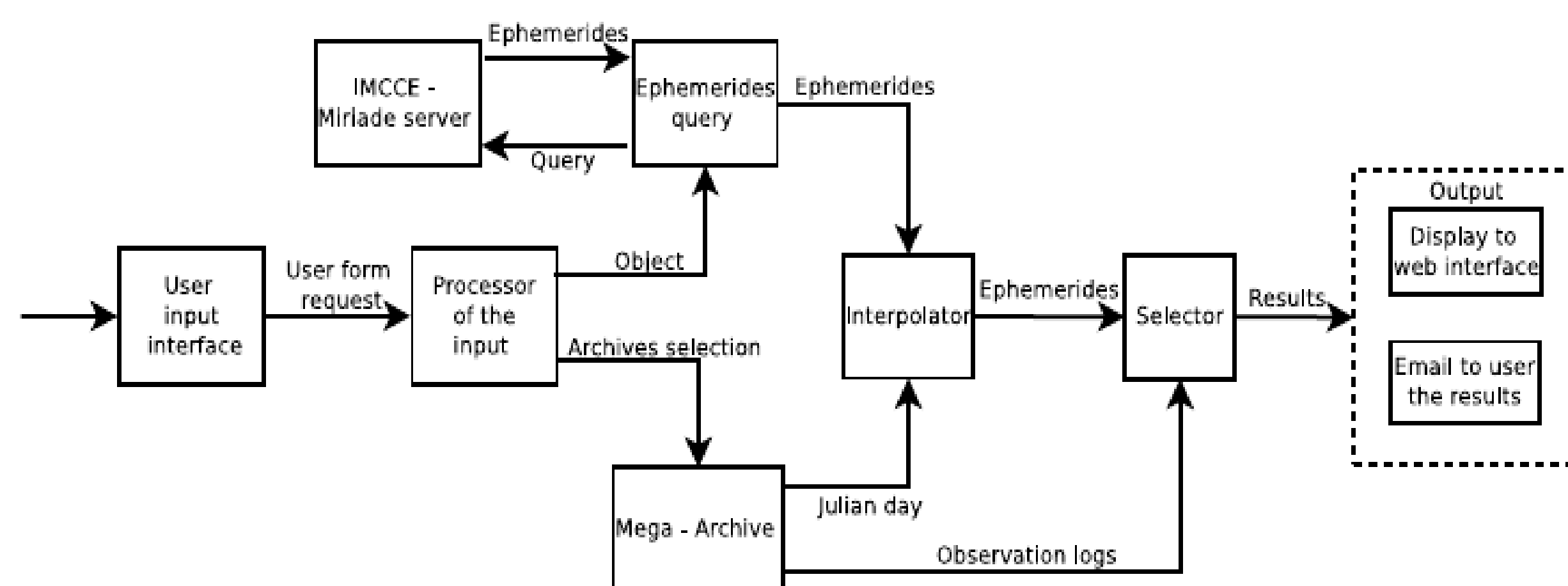
**Photometry** - determine the lightcurve of asteroids based on existing images.  
 - Example: 2006 KV89: 40 images in the interval 2455535+[0.73; 0.90]

## MEGA-PRECOVERY STRUCTURE

**Mega-Archive** database which includes the individual instrument archives, namely the observing logs pointing to the science CCD images or plates available from a collection of instruments and telescope around the globe. The Mega-Archive is an open project allowing other instrument archives to be added later for exploration by anybody who would like to contribute [1].

**Mega-Precovery** software for data mining the Mega-Archive for the images containing one or a few catalogued objects (NEAs, PHAs or other Solar System Objects) included in a local daily updated MPC database. The Mega-Precovery software is written in PHP, being embedded on the EURONEAR website as a public access application under the observing tools section [1].

**The output** consists in a list including the images predicted to contain the queried object(s). The results are displayed both in the web interface (visible at the end of the run) and sent via e-mail to the user (in case this option was selected). The user can search the images in the online instrumental archive, then download, inspect and measure the candidate image to hold the searched object according to your science interests [1].



The flowchart of Mega-Precovery. Reference : [1]

## INTRODUCING AΩA (ARCHIVAL ETENDUE) FACTOR

Giving the grow of the archives, we propose the new following factor:  
**AOMegaA - archival etendue** = the product between collecting area of the telescope, collecting area field of view of the camera and the number of images.  
 Thus, AOMegaA = AOMega x number of images;

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	
Telescope	Instrument	AΩ (etendue)	AΩA	[k]	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	Interval covered
VLT	EFOSC2	0.2	12																							03 Jul 2004 - 16 Mar 2012	
VLT	FOPSS	0.7	24																							23 Jan 1999 - 26 Mar 2009	
VLT	FOPSS	0.7	75																							30 Oct 1999 - 25 Feb 2012	
VLT	HAWKI	0.8	57																							01 Aug 2007 - 24 Feb 2012	
VLT	ISAAC	0.1	19																							01 Mar 1999 - 25 Feb 2012	
VLT	NACO	0.0	4																							02 Dec 2001 - 29 Feb 2012	
VLT	VIMOS	3.1	204																							30 Oct 2002 - 28 Feb 2012	
VLT	VISIR	0.004	0																							11 May 2004 - 26 Feb 2012	
VST	OMEGACAM	5.4	103																							16 Dec 2009 - 22 Jun 2011	
NTT	EMMI	0.2	4																							01 Apr 2011 - 15 Mar 2012	
NTT	SOPH	0.1	8																							17 Mar 2004 - 01 Apr 2008	
NTT	SUSI2	0.1	1																							30 Mar 2006 - 15 Feb 2012	
3.6m	TIMMI2	0.005	0																							02 Apr 2004 - 29 Dec 2008	
MPG	WFI	1.3	133																							08 May 2004 - 28 Jun 2006	
KPNO	MOSAIC	4.5	149																							25 Oct 1999 - 25 Feb 2012	
KPNO	NEWFIRM	2.7	356																							01 Sep 2004 - 07 Feb 2013	
WYN	Mini Mosac	0.3	2																							30 Jun 2007 - 04 Feb 2013	
WYN	WHIRC	0.03	2																							17 Mar 2009 - 18 Oct 2012	
WYN	MOSAIC	0.6	5																							04 Apr 2009 - 01 Dec 2012	
CTIO	MOSAIC-2	4.8	325																							27 Mar 2009 - 20 Sep 2012	
CTIO	NEWFIRM	2.7	203																							11 Aug 2004 - 20 Feb 2012	
CTIO	Class. Imp.	0.03	7																							18 May 2010 - 17 Oct 2011	
CFHT	Megacam	9.1	1304																							16 Mar 2009 - 15 Jan 2013	
INT	WFC	1.5	578																							22 Feb 2003 - 09 May 2013	
INT	WFC	1.5	578																							20 Jun 1998 - 28 Feb 2013	
SUBARU	SuprimeCam	13.5	948																							05 Jan 1999 - 02 Jul 2011	
AAT	WFI	3.6	14																							21 Aug 2000 - 05 Feb 2006	
SDSS		7.4	34536																							19 Sep 1998 - 16 Nov 2009	
DAD	EVZ CCD	0.4	1																							11 Feb 2008 - 07 Mar 2011	
Gemini-S	MOS	0.4	9																							27 Feb 2003 - 11 Oct 2011	
Gemini-N	MOS	0.4	7																							21 Oct 2001 - 03 Oct 2011	
MACHO		2.9	354																							20 Jun 1992 - 19 Nov 2002	
CFHT	WFC	1.5	578																							14 Jun 2006 - 01 May 2013	
HST	ACS	0.3	28																							01 Apr 2002 - 27 Jan 2007	
HST	NICMOS	0.1	0																							27 Nov 2002 - 21 Aug 2008	
HST	WFC3 NIR	0.2	7																							05 Jul 2009 - 15 Nov 2012	
HST	WFC3 V	0.3	6																							13 Jul 2009 - 15 Nov 2012	
HST	WFPC2 NIR	0.3	0																							05 Mar 1994 - 06 Apr 2008	

We highlight in blue all instruments with AOMegaA > 500k sq.m x sq.deg.

## FURTHER IMPROVEMENTS

- New capabilities:**
- query by orbital elements;
  - query by observational arc;
- Database:**
- Daily updates of MegaArchive (in work)!
- Interface:**
- generate link to direct download the images;
  - select time interval for queering;
  - provide '.cfg' files to reduce images in Astrometrica.

## REFERENCES

- [1] Vaduvescu, O.; Popescu, M.; et al.; "Mining the ESO WFI and INT WFC archives for known Near Earth Asteroids. Mega-Precovery software", *Astronomische Nachrichten*, Vol.334, Issue 7, p.718-728, 08/2013;  
 [2] Popescu, Marcel, "Mega-Precovery, a dedicated project for data mining worldwide image archives", <http://www.diaspora-stiintifica.ro/diaspora2010/prezentare18.html>

\* Want to add your image archive to Mega-Precovery? Email: [euronear@imcce.fr](mailto:euronear@imcce.fr)